The Formation and Double Decomposition of Pyridoxal Isonicotinoylhydrazone Dimethiodide Mediated by Iron(II) Salts

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Iron(II) ions are shown to induce a hitherto unknown nitrogen-centred metathesis ('hydrazine metathesis') of pyridoxal isonicotinoylhydrazone dimethiodide (**1**) into the symmetrical hydrazine derivatives pyridoxal azine dimethiodide (**7**) and dimethiodide of bis-isonicotinoyl hydrazide (**8**) together with isonicotinoylamide methiodide (**9**) in a ratio 2 : 1 : 1, respectively.

X-Ray structural analysis and Mössbauer spectroscopic studies have shown that the reaction of the free form of pyridoxal isonicotinoylhydrazone (PIH)[1] with Fe^{II} ions proceeds with retention of its neutrality by transfer of protons from the phenol oxygen and the hydrazide nitrogen to the two pyridine nitrogens. The diprotonated form of co-ordinated PIH appears to function as an electron transfer oxidant to yield a $[PIH]_2Fe^{III}$ complex.[2] To gain insight on intramolecular metal–ligand electron transfers[3] in the π-system of the chelator, PIH was methylated at its pyridine nitrogens and exposed to Fe^{II} ions in hydroxylic solvents.

We now report the first example of an Fe^{II} induced nitrogen-centred metathesis† of pyridoxal isonicotinoylhydrazone dimethiodide (**1**) into a 2 : 1 : 1 mixture of pyridoxal azine dimethiodide (**7**), di-isonicotinoylhydrazide dimethiodide (**8**), and isonicotonoylamide methiodide (**9**), respectively.

The title compound (**1**), orange–yellow crystals, m.p. 180 °C, was prepared (80%) by treating PIH with a 10-fold excess of MeI in boiling dimethylformamide (DMF) for 5 min. It exhibited the corresponding u.v. bands (MeOH) of the parent compound (PIH) at longer wavelengths with higher intensities at 222, 323, and 352 nm, and a new band at 425.7 nm (ε 7700), attributable to the dipolar form.[5,6]‡

The addition at room temp. of $FeSO_4 \cdot 7H_2O$ (0.14 g) to (**1**)

† This is the first nitrogen analogue of the common 'olefin metathesis,'[4] involving sp^2 nitrogen atoms in place of sp^2 carbons.

‡ I.r. (KBr): 1690, 1645, 1555 cm^{-1}; ^1H n.m.r. (300 MHz) (Me_2SO): δ 9.318, 9.296(2H), 8.969(1H), 8.62(1H), 8.543, 8.529(2H), 4.80(2H), 4.454(3H), 4.29(3H), 2.702(3H); mass spectrum (electron impact) (*m*/*z*): 286(*M*−2MeI), 141 (CH_2I).

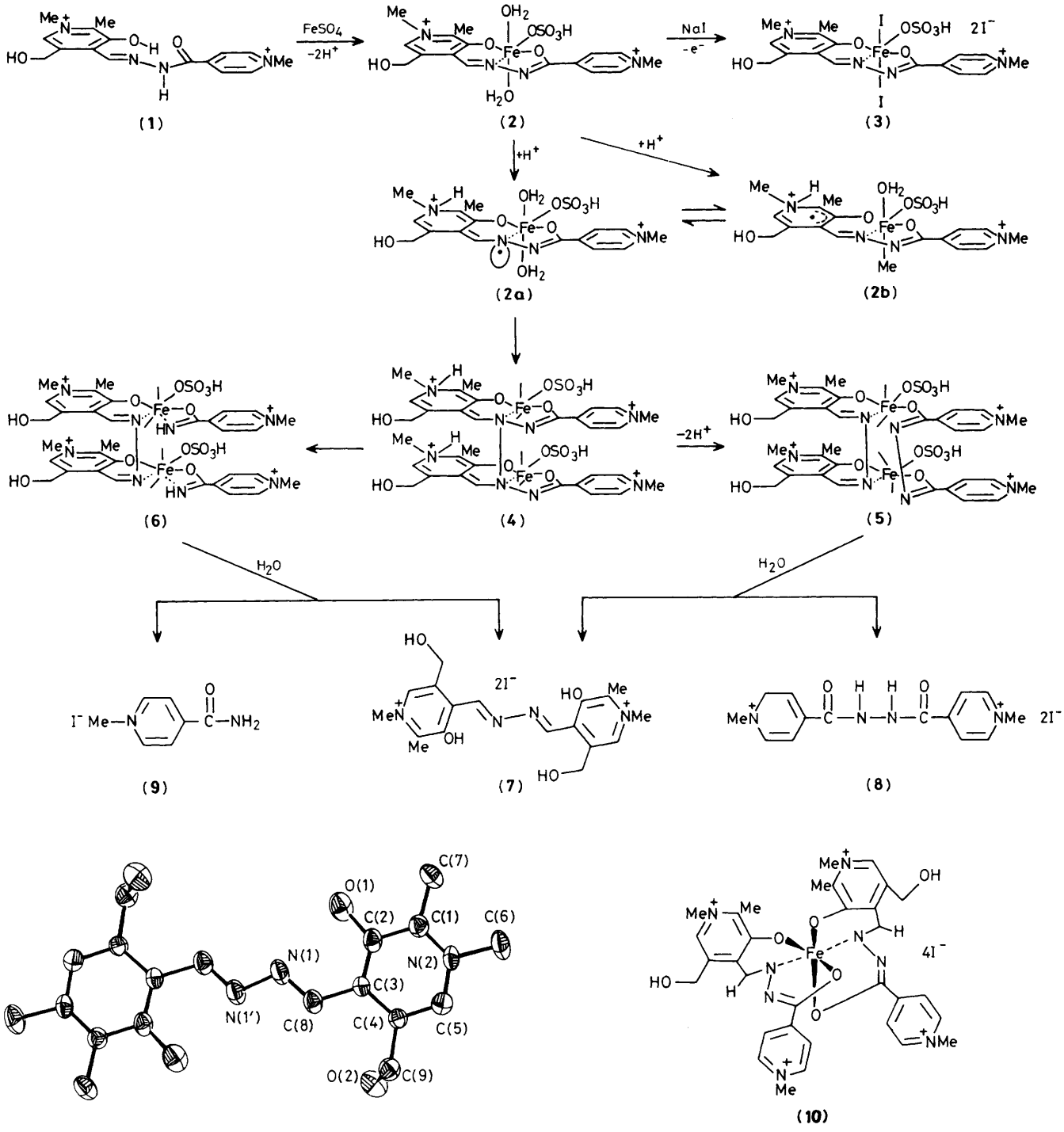

Figure 1. A perspective view of pyridoxal azine dimethiodide (**7**) with atom labelling. Thermal ellipsoids are drawn at the 50% probability level. Bond lengths (Å) and bond angles (°): O(1)–C(2) 1.35(1); O(2)–C(9) 1.40(1); N(1)–C(8) 1.27(1); N(1)–N(1′) 1.418(9); N(2)–C(1) 1.34(1); N(2)–C(5) 1.36(1); N(2)–C(6) 1.51(1); C(1)–C(2) 1.40(1); C(1)–C(7) 1.51(1); C(2)–C(3) 1.38(1); C(3)–C(4) 1.41(1); C(3)–C(8) 1.47(1); C(4)–C(5) 1.36(1); C(4)–C(9) 1.50(1); C(8)–N(1)–N(1′) 113.1(8); C(1)–N(2)–C(5) 122.4(9); C(1)–N(2)–C(6) 120.6(8); C(5)–N(2)–C(6) 117.0(8); N(2)–C(1)–C(2) 117.8(9); N(2)–C(1)–C(7) 120.3(9); C(2)–C(1)–C(7) 121.9(8); O(1)–C(2)–C(1) 115.0(8); O(1)–C(2)–C(3) 123.7(9); C(1)–C(2)–C(3) 121.3(8); C(2)–C(3)–C(4) 118.5(9); C(2)–C(3)–C(8) 121.3(8); C(4)–C(3)–C(8) 120.2(8); C(3)–C(4)–C(5) 118.6(9); C(3)–C(4)–C(9) 123.1(9); C(5)–C(4)–C(9) 118.2(8); N(2)–C(5)–C(4) 121.3(9); N(1)–C(8)–C(3) 119.9(9); O(2)–C(9)–C(4) 111.0(8).

(0.57 g 1 mM) in 20 ml H_2O led to an acidic (pH~3) dark-green solution (**2**), (**2a**), (**2b**), changing into green–black on standing. The soluble 1 : 1 Fe^{III} complex (**3**)§ could be precipitated by saturating the reaction mixture with NaI. The black $[Fe(C_{16}H_{18}N_4O_3)I_4]HSO_4{\cdot}2H_2O$ compound (**3**) exhibited six u.v. bands at 201.8, 225, 269, 326.6, 379, and 476 nm (ε 2060), of which the last one could be attributed to a M → L charge-transfer electronic transition.[6c] The same Fe^{III} complex (**3**) was obtained upon adding $Fe_2(SO_4)_3$ to (**1**) followed by addition of NaI. If the reaction mixture was allowed to

§ Essentially, (**3**) is the dimethiodide derivative of the parent 1 : 1 Fe^{III}–PIH complex reported earlier by Murphy and his coworkers.[7]

evaporate at room temp. (*ca.* 48 h), mixed crystals were obtained from which it was possible to isolate red–orange, metal-free, crystalline $C_{18}H_{24}N_4O_4I_2$, m.p. 264—265 °C. Its structure was determined by single crystal *X*-ray analysis (see Figure 1), shown to be the dimethiodide of pyridoxal azine (**7**).¶ Compound (**7**) was also synthesized (90%) by treating pyridoxal azine[8] with an excess of MeI in boiling pyridine.‖

Small quantities of the metathesis products, (**8**) and (**9**), in pure forms could be obtained by h.p.l.c. (H_2O–MeOH). Larger quantities of the latter were synthesized by treating respective parent compounds with excess of MeI in boiling pyridine; (**8**) m.p. 285 °C, u.v. (MeOH): 221, 266, 417.6 nm (ε 6600); (**9**) m.p. 258—259 °C,[9,10] u.v. (MeOH): 223, 266, 341 nm (ε 53).

If mixing of (**1**) with $FeSO_4$ in H_2O was followed by addition of NaOH to reach pH~6, the corresponding Fe^{III}-complex (**10**), contaminated with some (**7**), crystallized out. A pure sample of $[Fe(C_{16}H_{20}N_4O_3I_2)_2]_2SO_4$ (**10**) was obtained by treating iron(III) bis(pyridoxal isonicotonoylhydrazone)[2] (0.11 g) in DMF (2.5 ml) with boiling MeI (0.5 ml) for a few min.; black powder, u.v. (H_2O): 472 nm (ε 8430) and bands at 378, 327.8, 287, and 227.6 nm.

Evidently, iron(II) ions induce the acyl hydrazone (**1**) to enter into a hitherto unknown bond reorganization, resulting in redistribution of the hydrazine moieties ('hydrazine metathesis'). The reaction could be envisaged to arise from chelation of Fe^{2+} to yield an Fe^{II} complex (**1**) → (**2**), undergoing an intramolecular single-electron-transfer to form free-radical species (**2a**), (**2b**).[11—16] The azomethinyl radical (**2a**) could be stabilized either (i) by delivering the retained electron to a suitable acceptor in the environment, or else, (ii) by undergoing dimerization to form a short-lived tetrazene-containing complex (**4**). This species seeks further stabilization by redistribution of the hydrazine moieties to yield the stable products (**7**)—(**9**).

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¶ *Crystal data* for (**7**): $C_{18}H_{24}N_4O_4I_2$, M = 868.01, a = 14.843, b = 6.584, c = 11.946 Å, β = 106.08°, U = 1121.8 Å^3, Z = 2, space group $P2/c$. 1556 Unique absorption-corrected data with $I \geq 3\sigma(I)$ were selected from 1954 recorded intensities: R = 0.059. The atomic co-ordinates for this work are available on request from the Director of the Cambridge Crystallographic Data Centre, University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW. Any request should be accompanied by the full literature citation for this communication.

‖ Selected n.m.r. data (25 °C, Me_2SO): (**7**), ^1H, δ 9.867, 9.848(1H), 8.636(2H), 8.428(2H), 8.171(2H), 6.828(2H), 5.179(3H), 4.577(3H), 2.72(3H), and 2.578(3H); ^{13}C, δ 125.86(CH_2O), 90.25(CH_2O), 69.83(MeN), 14.80 (MeC), and 14.57 (MeC).

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